Fuels NG and Propane in Gasoline Engine

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Abstract- **Biofuels are fuels that are in essence biodegradable and non toxic. Moreover, they are manufactured from vegetable oils, waste cooking oils, animal fats and from recently living organisms. They can be divided into three categories: 1) first-generation biofuels which are made largely from edible sugars and starches; 2) second-generation biofuels, which are made from nonedible plant materials and; 3) third-generation biofuels, which are made from algae and other microbes. Advanced biofuels can offer environmental benefits such as emit less particulate pollution than other fuels and particularly fuels that are based on petroleum. They are renewable sources of energy, thus you can just keep produce more, cheaper than diesel and finally, they can reduce dependence on foreign oils. The present paper examines the use of fuel gases (propane, natural gas) in a small four-stroke engine of internal combustion, which it is used for the movement of a small alternative generator. The electrical generator functioned without load and under different loads (500, 1000, 1500 and 2000 W), using as fuels gasoline and fuel gases. During the tests, it has been observed the CO and HC emissions for every fuel and load condition. The use of natural gas as fuel had as a result the CO and HC emissions decrease under different load. The flow of fuel gases was regulated so that until the load of 2000W the behavior of the engine from the aspect of efficiency to be the same with that of gasoline. This means that the engine rpm was the same for every electrical load in both fuels gasoline and fuel gases. During the tests, the consumption of gasoline and fuel gases were recorded and it has been noticed that they were increased when the electrical load was increased too. As far as the consumption of fuel gases is concerned, it has been noticed that it gives the same engine behavior from the aspect of power and engine rpm that the manufacturer gives for the use of gasoline.**

Key Words- Gas Emissions; Propane; Natural Gas

I. INTRODUCTION

In nowadays the use of biofuels is necessary as they don't contribute to global warming, which is air pollution. Air pollution occurs when the air contains gases, dusts, fumes or other substances in harmful amounts that could be harmful to the human health and animals or could cause damage to plants and materials. The substances that cause air pollution are called pollutants. Pollutants can be either primary or secondary. Moreover, primary are the pollutants that pumped into the atmosphere and directly pollute the air, while the secondary is the result from the primary pollutant which takes part in further chemical reactions once they are in the atmosphere. Some of the main types of air pollution are smog, acid rain, the greenhouse effect and holes in the ozone layer. It is important to mention that air pollutants they know no borders and travel easily from their sources towards other locations spreading pollution throughout the world. Depending on the geographical location temperature wind and weather factors, pollution is dispersed differently. Air pollution can affect human health in many ways with both short and long term effects. Examples of short term effects include irritation to the eyes, nose, throat, while long term health effects can include heart disease, lung cancer and chronic respiratory disease. Health impact of air pollution depends on the pollutant type, its concentration in the air and length of exposure. Different people are affected by air pollution in different ways. Furthermore, very young, very old, and poor people are more at risk than others. Apart from human health, air pollution affects animals and plant life. Plants and insects are a food source for animals, so damage to either can harm wildlife. Air pollution can also damage materials, the exterior surfaces of buildings, the paint of the cars and also the marble monuments [1]. The rapid growth in urban population, the increase of industrialization and the rise of demands for energy and motor vehicles have contributed to the worsening air pollution levels in developing country cities. The main pollutants from car emissions are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x) and particulate matter. When carbon monoxide is present in the lungs, displaces oxygen from hemoglobin and reduces the amount of oxygen that can be delivered to the tissues [2]. Unburned hydrocarbons that are produced from incomplete combustion of the fuel can cause cancer to humans and they also have the role of precursors of photochemical ozone. The pollutants nitrogen oxides are nitrogen oxide (NO) and nitrogen dioxide (NO_2). Exposure to oxides of nitrogen includes human respiratory problems and damages to plants. Nitrogen dioxide takes part in photochemical smog reactions and when oxidized to nitric acid is contributes to acid rain formation [3].

A number of parameters, such as the fuel and air mixing, the temperature of combustion, the time available for combustion in the engine, effect the vehicle exhaust emissions [3]. The fuel that is used to power the engine is a factor that also influences emissions. When alternative fuels are used instead of the usual petroleum-based fuels, the vehicular emissions are reduced [4].

Propane and butane as blend is an alternative to gasoline and diesel and can be used in internal combustion engines as fuel. Propane-butane is a mixture of liquefied hydrocarbons and in liquid state is a colorless liquid that is volatilized easily. This liquefied gas can be derived during crude oil processing and the further processing of intermediate refinery products during petrol reforming, vacuum oil cracking, hydro cracking, soft asphalt desulfurization and pyrolisis of petrol and natural gas [5, 6, 7, 8, 9]. This mixture is stored and transported in pressurized tanks in liquid form but is used in its gaseous state. The use of propane-butane mixture has many advantages. Both propane and butane are alkenes with simple hydrocarbon structure and they are relatively uncreative, which means that are safe for use. The fact that they can be stored in pressure tanks means that they are portable and can be transported and stored where natural gas grid does not exist. Because propane and butane are gases that when they enter into the engine, they achieve better mix with air in the engine, which allows almost complete combustion. This also minimizes problems with starting the engine in cold weather. When the mixture of

propane and butane is use as an alternative to gasoline, produces cleaner exhaust fumes [3, 5, 10, 11, 12]. Besides that, the amount of propane and butane that escape to the atmosphere is small and the vapors have low reactivity compared to gasoline, which means that they have lower ozone forming tendency. Generally the mixture of propane and butane has good combustible properties, high-energy value and perfect ecological and economical properties.

One of the alternative fuels that can be used is natural gas. Natural gas is a mixture of hydrocarbon and non-hydrocarbon gases which occurs naturally and is found in porous geological formations that are called reservoirs, beneath the earth's surface. The chemical composition and the Btu content of natural gas vary with the reservoir source, processing conditioning steps and the kind of pipeline used. Processed natural gas is primarily a mixture of paraffinic hydrocarbons with the following median composition: methane (93%), ethane (3.1%), propane (0.5%), isobutane (0.06), n-butane (0.05), isopentanes (0.02), n-pentane (0.02), hexanes (+ 0.04), along with N_2 (1.2%), and CO_2 (0.6%). Odorants (tert-butyl Mercaptan) are added for safety purposes. Low levels of H_2O vapor, H_2 CO, He, O_2 and C_6-C_{14} hydrocarbons are normally considered “negligible” constituents of most processed natural gas streams. In order to increase Btu content of processed natural gas it can be blended with reformed gas on a seasonal basis [13, 14, 15, 16]. Besides the use of natural gas as fuel, natural gas is a feedstock (hydrogen source) for ammonia production and a source of light hydrocarbons (ethane, propane, butane) for chemical synthesis or LG products [5, 6]. Although in atmospheric natural gas is a gas, when it is used in internal combustion engines is in a liquid form and it is stored in cylinders and tanks.

The question that is examined in this paper is how the fuel gases (propane, natural gas) behaves in a four-stroke engine from the aspect of emissions, function and fuel consumption.

II. INSTRUMENTATION AND EXPERIMENTAL RESULTS

The experimental measurements were carried out on a four-stroke, air-cooled engine. This is a one-cylinder engine with 162cm^3 displacement that is connected with a phase single alternative generator (230V/50Hz) with maximum electrical load approximately 3.5KVA(Figure 1). The engine according to the manufacturer uses gasoline as a fuel. The engine functioned without load and under different loads 500W, 1000W, 1500W and 2000W, using as fuels gasoline and natural gas. During the tests, exhaust gases measurements, were also monitored for every fuel and for every load conditions. Also, during the function of the engine the consumption was recorded for every fuel. There was lack of engine regulation concerning the stable air/fuel ratio. For this purpose, the ADVANTECH PCI-1710HG Data Acquisition cart was used with the terminal wiring board PCLD-8710 with on-board Cold Junction. The data acquisition card was installed at a Pentium II PC at 266MHz. This particular measuring system and software completed a scanning cycle per channel every 0.1 second approximately. This measuring speed was considered adequate for the purpose of the experiment and the sampling capabilities of the chemical sensors. For the exhaust gas measurements a HORIBA MEXA-574GE analyzer was used. This unit has the following ranges: CO: 0-10% volume and HC: 0-10000 ppm. The operating principle of this unit for the CO, HC measurements is the Infrared Non Dispersive Spectrometry. The time response for the CO, HC measurements is <=10 s. This unit is adequate for the steady state operation measurements required. The unit has a ± 2% accuracy and a ± 2% repeatability.

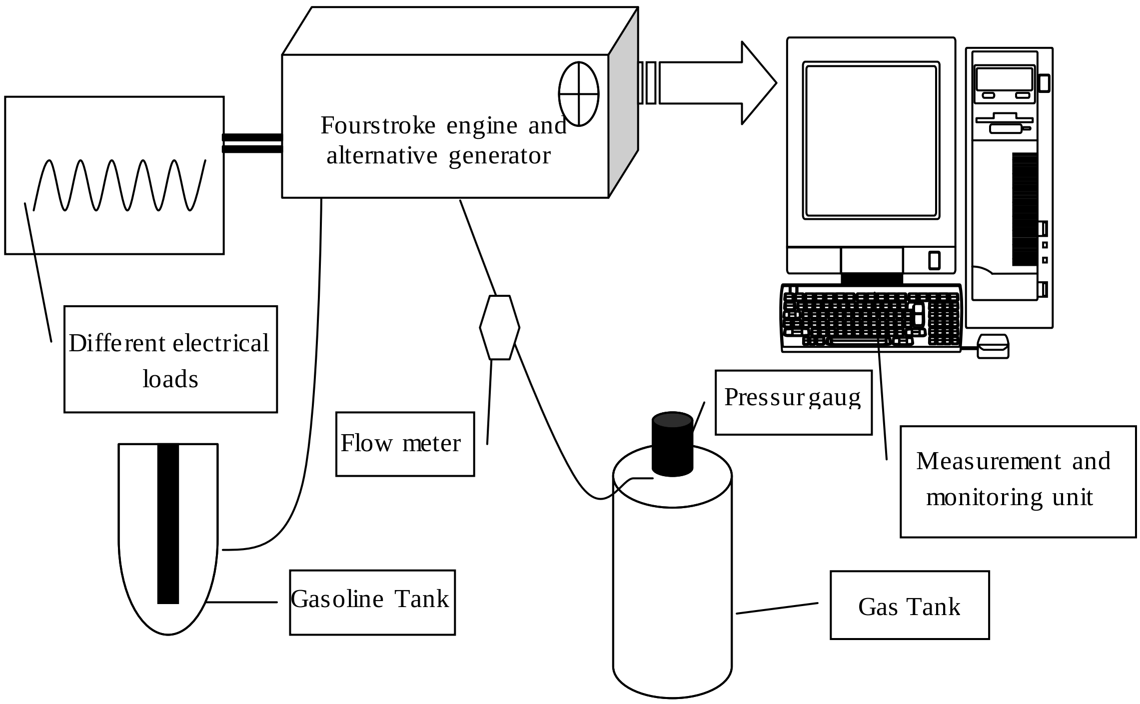

Fig. 1 The illustration of the experimental unit

It must be mentioned that the regulation of the engine for the use of gasoline was the original, while for the use of natural gas was regulated in the quantity of gases in order not to have power decrease of the engine with load conditions. The power decrease is shown through the rpm decrease. Therefore, the regulation was made in order to maintain the engine rpm stable at 2000W load, as in the case of gasoline use. The engine rpm for the use of gasoline and gases for the cases without electrical load, for 500W, 1000W, 1500W and 2000W are represented in the figure below.

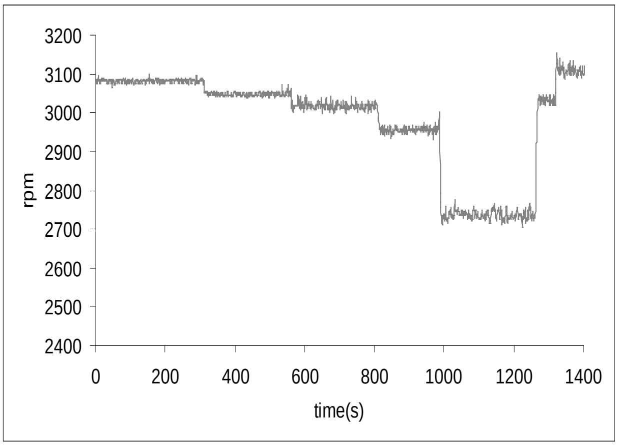

Fig. 2 The rpm variation when used different fuels: gasoline and gases

Fig. 2 presents the engine rpm variation with gasoline or gases in relation to the electrical load. The time period of 0-300s approximately refers to the function of the engine with gasoline or natural gas without load. The time period of 300-550s approximately refers to the function of the engine at 500W load. The time period of 550-800s approximately refers to the function of the engine at 1000W load. The time period of 800-1000s approximately refers to the function of the engine at 1500W load. From 1000s until 1250s the engine functions at 2000W electrical load. From 1250s until 1350s the engine functions at 1000W electrical load. Finally, from 1350s until 1400s approximately the engine functions at idle speed. Fig. 2 presents the rpm decrease when load increases. This decrease is normal and is among the determined limits of normal function of the engine-generator. The average values of the engine rpm in relation to electrical load are presented in Fig. 3:

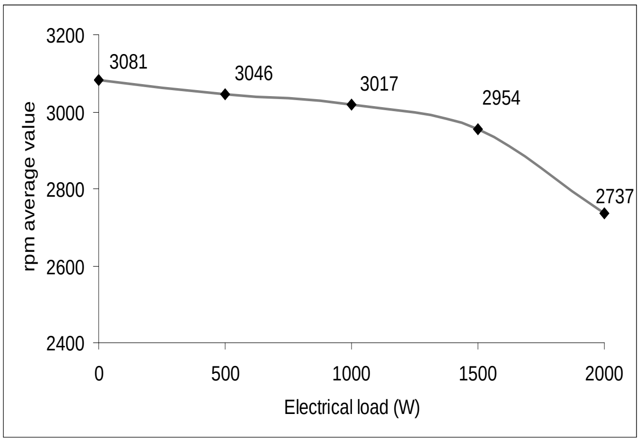

Fig. 3 The test rpm average value variation when used different fuels: gasoline, gases

The following figures presents the CO and HC emissions when is used as a fuel the gasoline and the gases for every load.

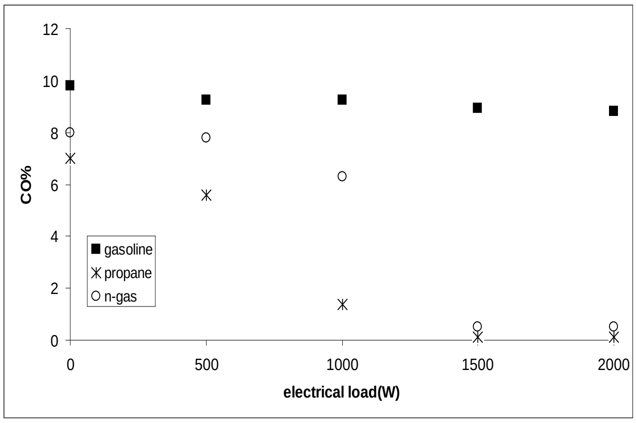

Fig. 4 The CO average value about gasoline and gases during the tests

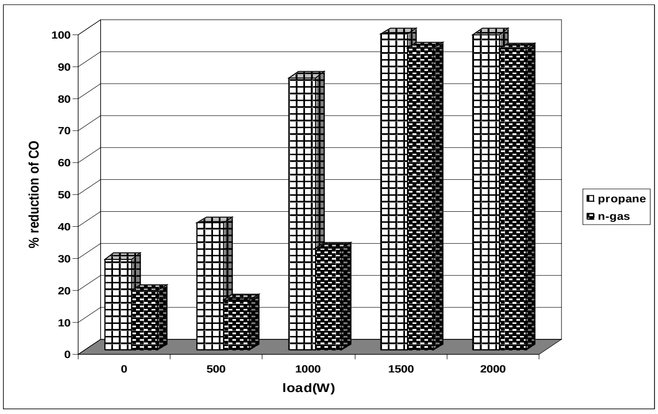

Fig. 5 The % reduction of CO average value of gases fuels compared to gasoline

Figs. 4 and 5 refer to the variation of CO emissions during the test for every electrical load and for every fuel separately (gasoline, gases). This figure is observed significant highest decrease of CO emissions during the use of propane gas as fuel in every load conditions tested. As for hydrocarbons their variation is shown in Figs. 6, 7:

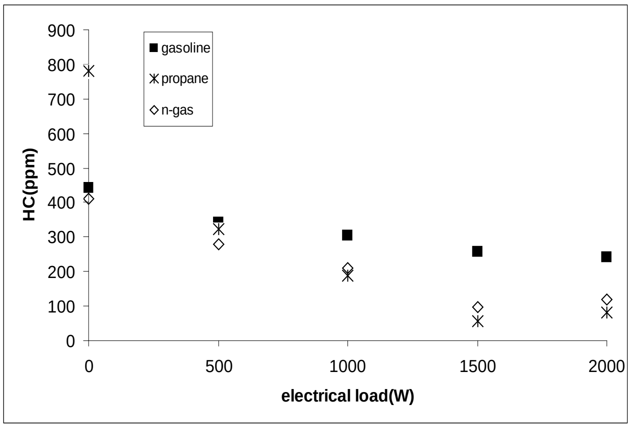

Fig. 6 The HC average value about the gasoline and gases during the tests

It can be seen from Fig. 6 that HC emissions decrease when propane gas is used as a fuel for 1000-1500-2000W electrical load. The behavior of the engine from the aspect of

rpm was the same for the use of gasoline and for the use of gases.

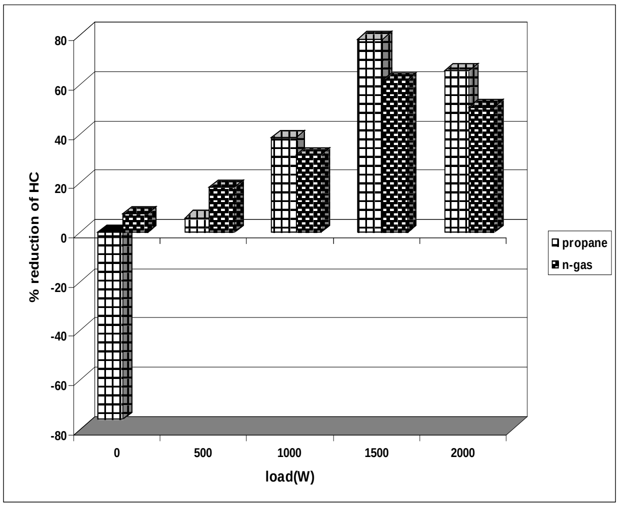

Fig. 7 The % reduction of HC average value of gases fuels compared to gasoline

From Fig. 7, it can be noticed that the biggest decrease occurs in the mixture of 80% but+20%pr when the load is 1500W.

As far as the consumption is concerned, the results are presented in the following figure.

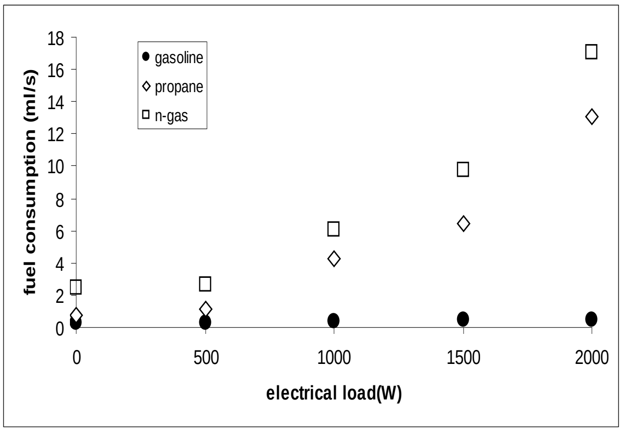

Fig. 8 The fuel consumption

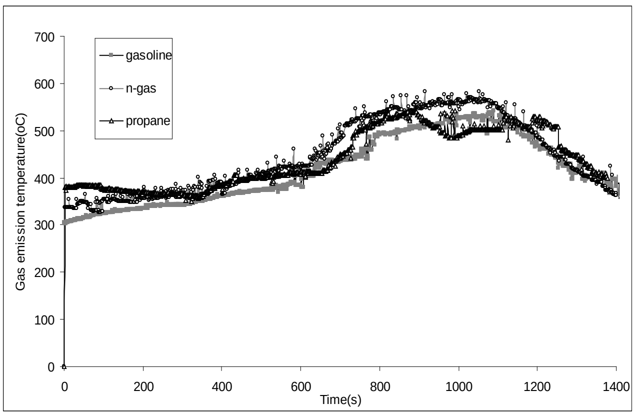

Fig. 9 The gas emissions temperature for any fuel

Fig. 8 appears the consumption of the fuels used in relation to different load conditions. It can be noticed that the consumption increases in both cases of gasoline and gases usage when the electrical load of the generator increases. It is important the fact of small consumption in the case of propane gas, always in relation to its cost. Also it must be mentioned that the measurements of gases consumption was made after being regulated the engine power until 2000W load, in order to be the same with the one that corresponds to gasoline as fuel, without any decrease of engine rpm [7, 8].

From Fig. 9, it can be concluded that in the case of gas emissions (n-gas, propane), the temperature of emissions is slightly increased due to the adjustment of the engine so that the gas consumption is such that there is no power failures.

III. CONCLUSION

Concluding, it can be said that the use of alternative fuels is necessary in order to reduce air pollution and consequently to protect human health, animals and planets. The transportation fuels that are made from biomass through biochemical on thermo chemical processes are known as biofuels. Biofuel is an alternative fuel that does not contribute to global warming, as the carbon dioxide they release when burnt is equal to the amount that the plants absorbed out of the atmosphere and therefore emits less pollution than other fuels, such as gasoline [9, 10, 11].

By taken into consideration all the above figures, it can be concluded that gases results in an (CO and HC) emissions decrease when the engine functions under different load conditions. The gases flow was regulated so that the engine behavior from the efficiency aspect, until the 2000W load, is the same with that of gasoline. This means that during the use of gasoline and during the use of gases the engine rpm for every electrical load conditions were the same [17, 18, 19]. From the aspect of consumption, there was a consumption increase when the electrical load increases in both cases of gasoline and gases use. Finally, from all gases fuels, the one that presented the lowest CO and HC emissions was gas propane (with the exception of HC without load, in where it has been observed an increase of HC emission, due to the adjustment of the engine). It was also the one that presented the lowest consumption too.

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